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Material Editing in Complex Scenes by Surface Light Field Manipulation and Reflectance Optimization (Supplemental Material)

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1. Introduction

This document provides notation tables and additional results.

2. Notation tables

Table 1, 2 and 3 show the sets, constants and general symbols used in our approach.

3. Additional result figures

Fig. 1 compares the results of $\mathcal{L}_0$, $\mathcal{L}_1$ and $\mathcal{L}_2$ optimization from the same user input. Fig. 2 and 3 show the effect of increasing / decreasing spatial resolution, directional resolution and gloss levels. Fig. 4 shows how different brush strokes results in different materials.

4. Tables

Symbol	Meaning
$\mathcal{M}$	Surface domain
$\mathbb{S}^2$	Spherical surface domain
$\mathcal{R}$	Set of reflectance fields
P	Set of locations of elements
$\mathfrak{R}$	Set of discrete reflectance fields
$\mathbf{g}$	Set of glossiness values for optimization. $\lvert\mathbf{g}\rvert = n_\mathrm{c}$
$\mathfrak{X}$	Set of solutions for different glossiness values

Table 1: *Symbol table for sets*

Symbol	Meaning
n_p	Number of elements
n_d	Number of directional bins
n_s	Dimension of shading model parameter vector
$\sigma_\mathrm{s}, \sigma_\mathrm{n}, \sigma_\mathrm{r}$	weight for position, normal, reflectance
n_c	Number of glossiness values for optimization
n_b	Number of bounces
σ_m	Manipulation tool weight
g_i	Glossiness value i used for search

Table 2: *Symbol table for constants*

Symbol	Meaning
$\mathbf{x}, \mathbf{y}$	Location
$\mathbf{n}$	Normal
$n(\mathbf{x})$	Normal at position $\mathbf{x}$
$\omega, \omega_\mathrm{i}, \omega_\mathrm{o}$	Direction; incoming, outgoing
$R(\mathbf{x}, \omega_\mathrm{i}, \omega_\mathrm{o})$	Spatially varying BRDF (reflectance)
$L_\mathrm{i}(\mathbf{x}, \omega)$	Incident radiance
$L_\mathrm{o}(\mathbf{x}, \omega)$	Outgoing radiance
$\mathbf{G}$	Geometry operator
$\mathbf{K}(R)$	Reflection operator
$\mathbf{T}^i(R)$	i-bounce transport operator
L_e	Emissive SLF
L_o^m	Manipulated SLF
R^m	New reflectance
$\mathbf{M}$	Manipulation operator
$m(\mathbf{x}, \omega)$	Manipulation stroke function
$l_\mathrm{o}(\mathbf{x}, \cdot)$	SLF for position $\mathbf{x}$
$s(\mathbf{x}, \mathbf{y})$	Similarity
$\Delta_\mathrm{R}(\mathbf{x}, \mathbf{y})$	BRDF difference function
$\Delta_\mathrm{r}(\mathbf{x}, \omega_\mathrm{i}, \omega_\mathrm{o})$	Change of reflectance
$R_\mathrm{f}(\mathbf{x}, \omega_\mathrm{i}, \omega_\mathrm{o})$	Final reflectance
$\mathbf{p}_\mathrm{i}$	Element i
$\omega_{i,j}$	Direction j of element i
$\mathbf{l}_\mathrm{e}$	Discrete Emissive SLF
$\mathbf{l}_\mathrm{o}$	Discrete SLF
$\mathbf{l}_\mathrm{o}^\mathrm{m}$	Discrete manipulated SLF
K_d	Diffuse reflection matrix
$\mathsf{K}_\mathrm{s}(\mathbf{f}_\mathrm{g})$	Specular reflection matrix
$\mathbf{r}$	Shading model parameter vector
$\mathbf{r}^\mathrm{m}$	New discrete reflectance
$\mathbf{r}_\mathrm{d}$	Diffuse components of the parameter vector
$\mathbf{r}_{\mathrm{d},i}$	Diffuse components of element i
$\mathbf{r}_\mathrm{s}$	Specular components of the parameter vector
$\mathbf{r}_{\mathrm{s},i}$	Specular components of element i
$\mathbf{r}_\mathrm{g}$	Glossy components of the parameter vector
$\mathbf{r}_{\mathrm{g},i}$	Glossy components of element i
$\perp(\omega, \mathbf{n})$	Reflection function
G	Discrete geometry matrix
$\mathsf{K}(\mathbf{f}_\mathrm{r})$	Discrete reflection matrix
$\mathsf{T}^i(\mathbf{f}_\mathrm{r})$	Discrete i-bounce transport matrix
$\mathrm{rep}(\mathbf{v}, n)$	Creates a vector were each entry of $\mathbf{v}$ is repeated n times
$\mathrm{diag}(\mathbf{v})$	Creates a diagonal matrix out of $\mathbf{v}$
W	Diagonal weighting matrix
$\mathbf{m}$	stroke vector $\in \{0,1\}^{n_\mathrm{p} n_\mathrm{d}}$
$\hat{\mathbf{x}}$	Least-squares fit for diffuse and specular shading parameters
$\alpha(\mathfrak{X})$	Selects the element with smallest residual magnitude from a set
$\mathcal{L}_2$	Least-squared optimization
$\mathcal{L}_0$	Zero-norm optimization
$\hat{\mathbf{x}}_\mathrm{d}$	Least-squares fit for diffuse if specular is fixed
$\hat{\mathbf{x}}_\mathrm{s}$	Least-squares fit for specular if diffuse is fixed
$\mathbf{h}$	index vector $\in \mathbb{N}^{n_\mathrm{p} n_\mathrm{d}}$

Table 3: *Other symbols table*

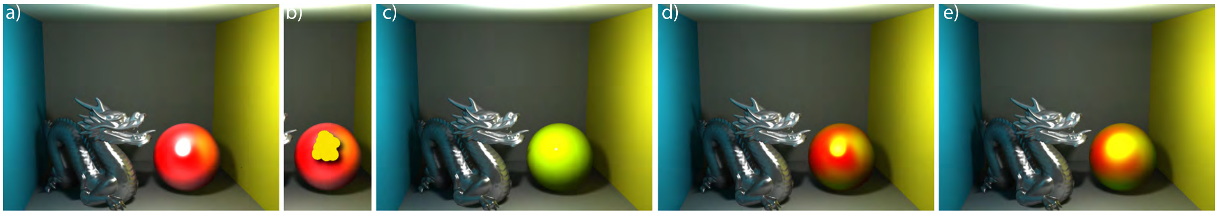

Figure 1: (a) *Input image and* (b) *stroke.* (c), (d), (e) *show result produced by the* $\mathcal{L}_2$, $\mathcal{L}_0$ *and "mixed" solvers respectively. The* $\mathcal{L}_2$ *solution turns objects into a diffuse-only material to match user's input. The* $\mathcal{L}_0$ *solution gives better result by keeping both old diffuse and old glossiness, modyfing only specular color. The "mixed" solver further improves the result by keeping only the original diffuse color and modifying both specular color and glossiness to match the user's input.*

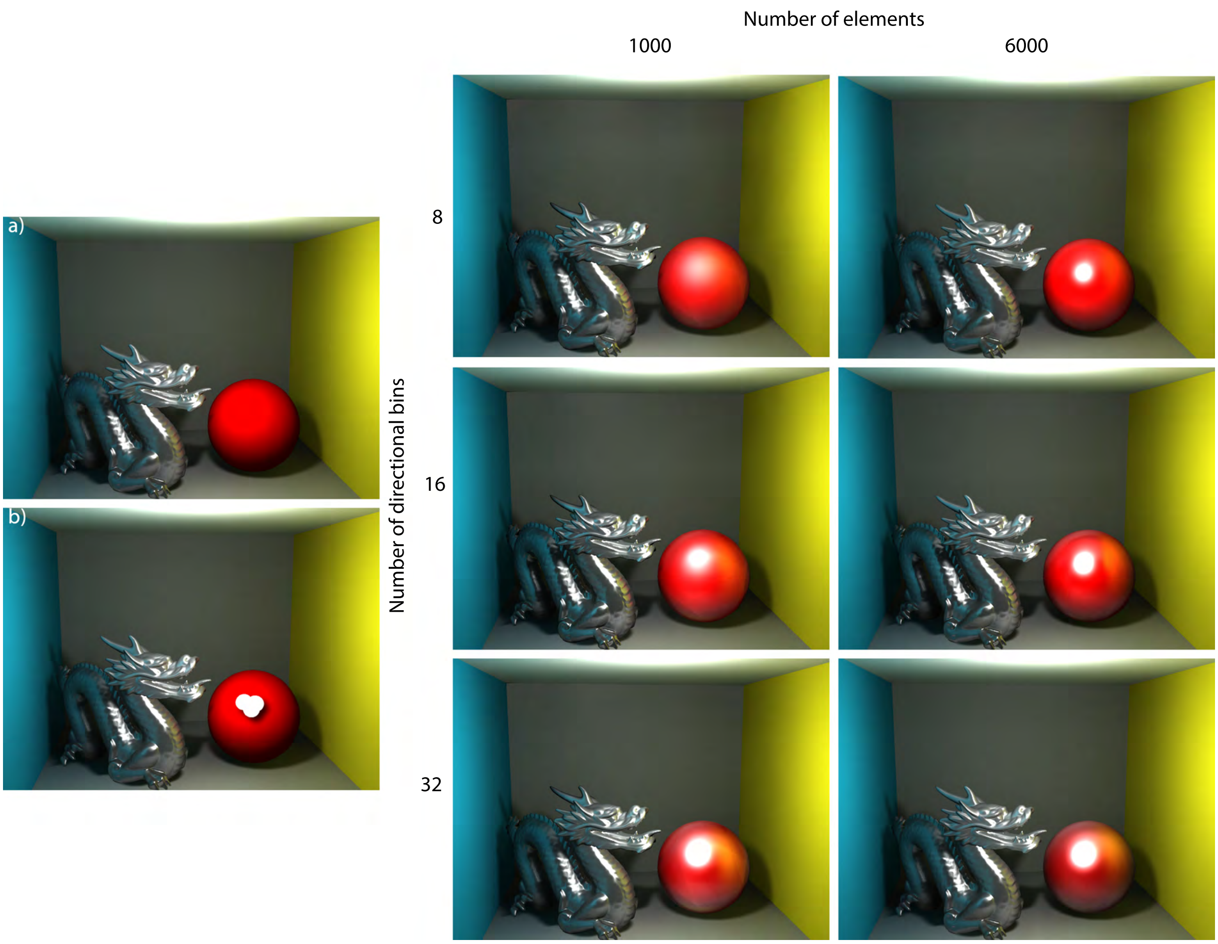

Figure 2: *Effects on spatial and directional resolution. The original image* (a) *and the input user's stroke* (b). *The images in the matrix show how our system performs with different number of element* (n_p) *and number of directional bins* (n_d). *The searching of glossiness values is fixed to* $n_\text{c} = 30$

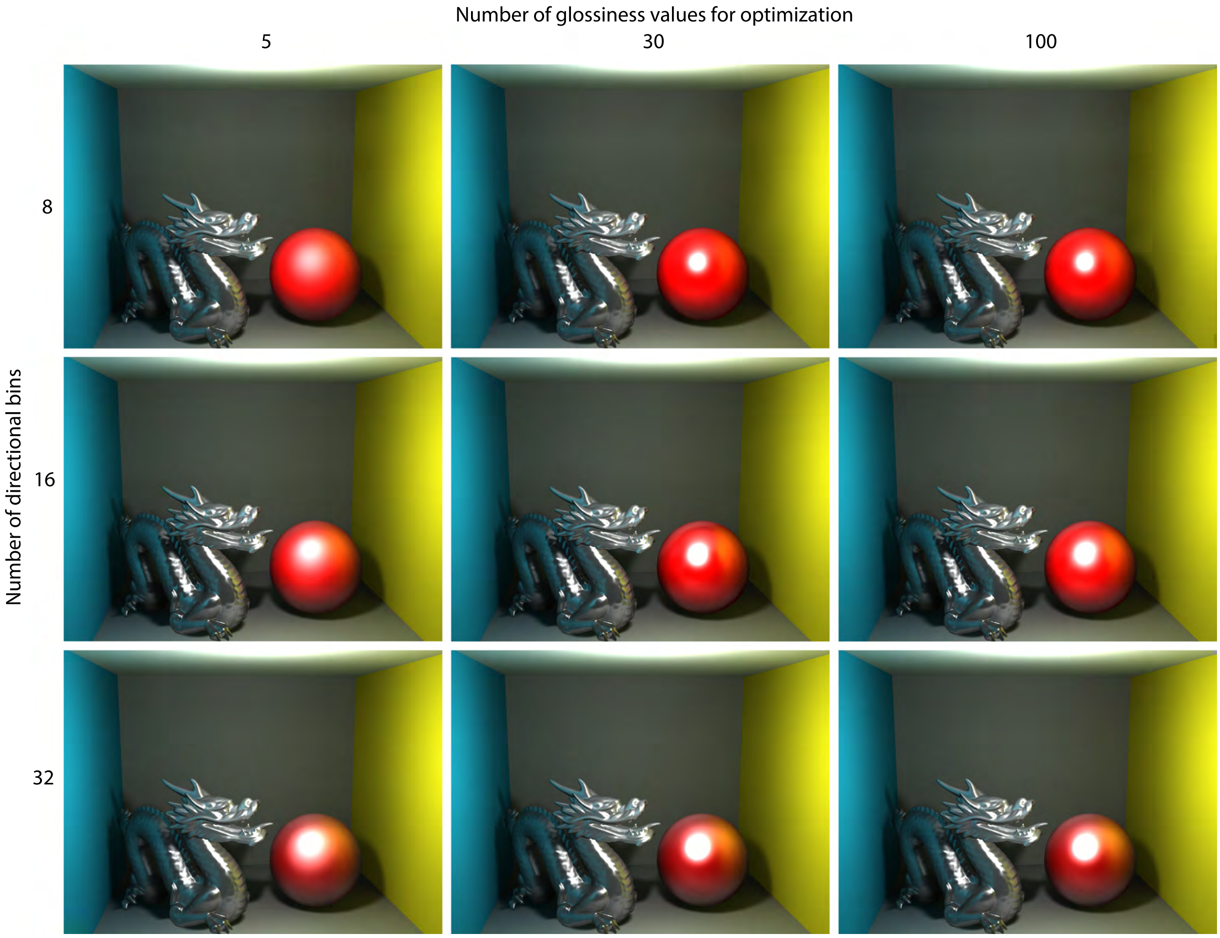

Figure 3: *Effects on gloss level and directional resolution. Scene and use input is the same as in Fig. 2. The matrix shows how our system performs with different nubmer of glossiness values* (n_c) *and directional bins* (n_d) *given the same number of element* $n_p = 6400$

Figure 4: *Effects of different brush size on the same object. The original image* (a)*, painted with different brush sizes* (b), (d) *results in* (c) *and* (e).